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A Note on the Indonesian Earthquake and Tsunami of 19 August 1977

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I Introduction

A strong earthquake and tsunami occurred in Indonesia on 19 August 1977. A report concerning this earthquake and the accompanying damage was completed by the Institute of Meteorology and Geophysics (IMG), Jakarta, Indonesia. Referring to the Indonesian report and clippings from Indonesian newspapers, the author introduces an outline of the earthquake and tsunami. Brief reference is made to local tsunami inundation mentioned in the IMG survey.

II Outline of the Earthquake and Tsunami

The people of Sumbawa Island in the Indian Ocean experienced a strong earthquake at about 13 h 00 m on Friday 19 August 1977; the earthquake originated at the southwest of the island. According to a report prepared by the Institute of Meteorology and Geophysics (1977),[1] the epicenter was determined to have been at the location of 118.6°E and 11.8°S and at a depth of 33 km below the surface. As a preliminary report, ITIC Newsletter[2] reported that the Pacific Tsunami Warning Center (Honolulu Observatory) gave a preliminary epicenter of 118.8°E and 10.5°S with a Richter magnitude of 7.7. The magnitude of the earthquake was eight on the Richter scale in the IMG report. At noon, before the main shock, a small earthquake of Richter scale 6.2 occurred.

Although the epicenter was located far from the coast and below the sea surface, a tsunami hit and caused material damage to the coast of the islands of Bali, Lombok, Sumbawa and Sumba. Damage directly caused by the earthquake was not very significant, most of it taking the form of cracks in the walls of buildings. But some cantilevers suffered structural distortion, involving partial or complete destruction due to the long duration of the horizontal ground motion. About 150 persons died or became missing and more than 1,000 persons were injured. The cost

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1) Pusat Meteorologi dan Geofisika. 1977. *Laporan gempa bumi Sumbawa tanggal 19 Agustus 1977*. Departemen Perhubungan, Jakarta, pp. 1–19.

2) ITIC. 1977. "Indonesian Tsunami of August 19, 1977," *ITIC Newsletter*, Vol. 10, No. 3, pp. 1–3.

of the damage caused by the earthquake amounted to Rp. 230,000,000.-.

Under some conditions, significant increase of the water level was observed in bays and river mouths, and it was in these places that most fishermen suffered injury. An enormous wave, more than 8 m in height, was reported in the district of Aik Ketapang Lunyuk, Sumbawa.

Those who did not know of the changes in water level after an earthquake were puzzled by the lowering of the water level which heralded the arrival of the destructive wave. In one district explosive sounds were heard a little time after the earthquake and before the arrival of the wave. Three sounds were reported. At the time the wave hit the shore the sea water became turbid and black in colour, and had a curious smell. In another district, the temperature of the sea water increased. The reason for this is not yet clear but one possible reason is absorption of heat from the sands of the beach.

Wave height increased under the effects of reflection and refraction.

On the beaches which did not face directly towards the epicenter, no waves generated by the earthquake were observed, and on some beaches the refracted waves were not so high as to cause any damage.

The astronomical tide consisted mainly of a semidiurnal tide with a period of 12 hours on that day, but the tide was observed to stay at low-water level for an abnormally long time. This phenomenon was observed in Waingapu, the capital of Sumbawa Timur.

Most of the people went out to the shore line to witness the abnormal phenomenon until noon. It was very fortunate that the tide level was low when the eatrhquake occurred on 19 August 1977, as this meant that the highest water level was relatively low even when the crest of the wave arrived.

When the sea level became high, some damage was caused by a big wave. The height of the tsunami varied from place to place.

This wave was generated as a result of the occurrence of the earthquake. And the height of a tsunami depends upon the magnitude of the earthquake. An earthquake with its center beneath the sea floor is accompanied by a big wave. And if the center of the earthquake is shallow, there may be a change in the profile of the sea floor in a vertical direction. Horizontal movement of the crust generally cannot generate a big wave.

The highest wave was observed at parts of the beach at the south of Sunda-Kecil Islands. This earthquake was noticed by observers in various places, especially by the International Tsunami Information Center which is located in Honolulu, Hawaii and the International Oceanographic Commission. Dr. Sidney O. Wigen and Dr. Dennis Segrit carried out a joint field survey from 25 August to 7 September 1977 with Dr. Susanto, the chief of Geophysical Section, the Institute of Meteorology and Geophysics, Jakarta.

III Local Tsunami Inundation—Summary of IMG Survey Report

The results of local tsunami inundation are given in the form of brief notes based on the findings given in the Indonesian report on the area, surveyed topographical conditions and remarks concerning the earthquake and tsunami. The geographical distribution of the tsunami damage along the coastline is shown as a hatched area in Fig. 1.

a) Nusa Dua, Bali: a bay; a reef at the center of the bay; the tsunami height was 2.5 m above mean sea level. The highest water level was 4 m. Three waves were observed.

b) Kosamba, Bali: no increase in water level.

c) Benoa Harbour, Bali: a bay of shallow water; hit by three waves of approximate height 1.5 m or less.

d) Labuhan Haji, Lombok Timur (Eastern Lombok): three strong earthquakes in one minute; the water receded initially. The first wave was the biggest. The tsunami height was 4 m. Black-coloured water inundated and withdrew over a range of 150 m.

e) Awang Coast, Central Lombok (the coast facing the channel): bay; the tsunami height was 4 m. All of the houses located in the coastal zone suffered damage.

f) Batunapur, Central Lombok (the coast facing the channel): bay; a shallow water area at the center of the bay; a small tsunami.

g) Kuta, Central Lombok (the coast facing the channel): a small reef was exposed; the water inundated about 300 m landward and withdrew as much as 200 m seaward. The sea level rose

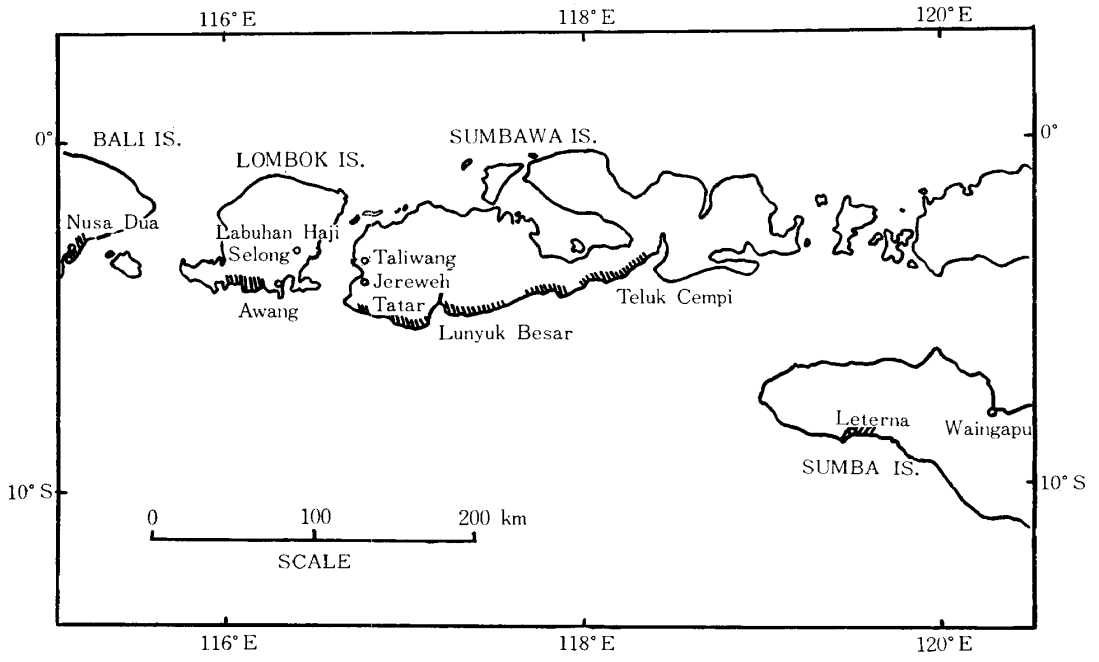

Fig. 1 Places where Tsunami Damage was Reported

Table 1 Damage Caused by the Earthquake and Tsunami

District	Personal Damage			Houses and Boats			Total
	Died	Missing	Injured	Houses	Boats	Equipment for Boats	
	persons	persons	persons				
1. Lombok	25	—	501	Rp. 63,000,000.	Rp. 19,000,000.	Rp. 15,800,000.	Rp. 97,800,000.
2. Lombok Timur	1	—	—	Rp. 200,000.	Rp. 9,600,000.	—	Rp. 9,800,000.
3. Sumbawa	81	54	624	Rp. 120,874,000.	Rp. 1,000,000.	—	Rp. 121,874,000.
4. Bima	—	—	—	Rp. 10,000,000.	—	—	Rp. 10,000,000.
Total	107	54	1,125	Rp. 194,074,000.	Rp. 29,600,000.	Rp. 15,800,000.	Rp. 239,474,000.

Remarks: This evaluation is for the area of Nusa Tenggara Barat. The Indonesian report noted that two persons died and damage was caused to at houses, clinics, bridges and fishing boats in the area of Nusa Tenggara Timur.
Currency rates on 29 August 1977 were Rp. 10,000.=¥6,514.=US$ 24.5 according to the Indonesian newspaper 'Indonesian Observer.'

Table 2 Local Damage Caused by the Earthquake and Tsunami

District	Personal Damage			Damage to Houses and Boats		
	Died	Missing	Injured	Houses	Boats	Equipment for Boats
	persons	persons	persons			
1. Lombok						
a. Teluk Awang	20	—	499	Rp. 23,000,000.	Rp. 13,200,000.	Rp. 13,200,000.
b. Kuta	1	—	—	Rp. 1,000,000.	Rp. 2,600,000.	Rp. 2,600,000.
c. Gerupuk	4	—	—	—	Rp. 1,300,000.	—
d. Selong Belanak	—	—	—	—	Rp. 1,900,000.	—
e. Primary school Teacher's houses				Rp. 37,500,000. (5 units) Rp. 1,500,000. (3 houses)		
2. Lombok Timur						
Labuhan Haji	1	—	—	Rp. 200,000. (1 public hall)	Rp. 9,600,000.	—
3. Sumbawa						
a. Lunyuk	65	37	339	Rp. 15,750,000. Rp. 20,500,000. (public buildings)	Rp. 1,000,000.	—
b. Tatar	13	—	170	Rp. 3,200,000.	—	—
c. Tenang	—	12	60	—	—	—
d. Molule	—	—	15	Rp. 750,000.	—	—
e. Empang	2	—	10	Rp. 11,750,000. Rp. 600,000. (warehouses)	—	—
f. Planpang	1	3	20	—	—	—
g. Ropang	—	2	10	—	—	—
h. Sumbawa Besar	—	—	—	Rp. 67,700,000. (buildings)	—	—
4. Bima	—	—	—	Rp. 5,000,000. (government offices) Rp. 5,000,000. (primary schools)		—

Remarks: Currency rates were Rp. 10,000.=¥6,514.=US$ 24.5 on 29 August 1977.

by as much as 5 m.

h) Ampenan Harbour, Lombok: no tsunami. The water was still.

i) Tatar, Jereweh, Sumbawa (the coast facing the channel): a strong earthquake was felt. No significant tsunami.

j) Aik Ketapang, Lunyuk Besar, Sumbawa: bay with a river inflow; the water withdrew 400 m and inundated 500 m. The tsunami height was 5 to 8 m.

k) Leterna, Sumba Barat (the coast facing the channel in Western Sumba): the tsunami height was 5 to 5.5 m above the still sea level.

l) Melolo, Sumba Timur (Eastern Sumba): the tsunami height slightly exceeded 1.5 m above the still sea level.

m) Waingapu New Port, Sumba Timur (Eastern Sumba): rather deep; wave height of 3 m and wave period of 2 to 3 min.

IV Remarks and Considerations

Damage to boats and their equipment was so significant that this experience of the earthquake and tsunami might have stimulated the people of Indonesia to take effective countermeasures on the coast. Local damage is tabulated in Tables 1 and 2. The author feels that he has to make the suggestion that it is necessary to carry out statistical analyses or time series analyses of past tsunami damage after compilation of the related records and documents, as well as dynamical analyses of the generation mechanism of tsunami and the response characteristics of the water of the coast and in the bays. As a preliminary work, the author has studied the probability of tsunamis in Indonesia with the assumption that tsunami occurrence follows a modified Poisson process.[3] In addition to the above, consideration of coastal structures might be also effective in devising countermeasures.

The author hopes that the people who suffered from the earthquake and tsunami will make a speedy and complete recovery.

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3) Nakamura, S. 1979. "On Statistics of Tsunamis in Indonesia," *South East Asian Studies*, Vol. 16, No. 4.